CALSTONE NOISE SURVEY
SUNNYVALE, CALIFORNIA

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INTRODUCTION

This report presents the results of a noise survey at the Calstone concrete products facility in Sunnyvale, California. The noise survey was conducted at the request of the City of Sunnyvale to establish property line noise levels at four locations identified by the City, to measure noise levels near significant sources of noise within the facility, and to identify any straightforward steps which could be taken to reduce noise. This report includes a brief discussion of community noise to assist the reader with the technical analysis, a summary of the City of Sunnyvale Noise Ordinance, the noise survey results, comments on the results vis-à-vis the ordinance, and noise reduction measures to be considered.

Background Information on Noise

Noise may be defined as unwanted sound. Noise is usually objectionable because it is disturbing or annoying. The objectionable nature of sound could be caused by its *pitch* or its loudness. *Pitch* is the height or depth of a tone or sound, depending on the relative rapidity (frequency) of the vibrations by which it is produced. Higher pitched signals sound louder to humans than sounds with a lower pitch. *Loudness* is amplitude of sound waves combined with the reception characteristics of the ear. Amplitude may be compared with the height of an ocean wave.

In addition to the concepts of pitch and loudness, there are several noise measurement scales which are used to describe noise in a particular location. *A decibel (dB)* is a unit of measurement which indicates the relative amplitude of a sound. The zero on the decibel scale is based on the lowest sound level that the healthy, unimpaired human ear can detect. Sound levels in decibels are calculated on a logarithmic basis. An increase of 10 decibels represents a ten-fold increase in acoustic energy, while 20 decibels is 100 times more intense, 30 decibels is 1,000 times more intense, etc. There is a relationship between the subjective noisiness or loudness of a sound and its level. Each 10 decibel increase in sound level is perceived as approximately a doubling of loudness over a fairly wide range of intensities. Technical terms are defined in Table 1.

There are several methods of characterizing sound. The most common in California is the *A-weighted sound level or dBA.* This scale gives greater weight to the frequencies of sound to which the human ear is most sensitive. Representative outdoor and indoor noise levels in units of dBA are shown in Table 2. Because sound levels can vary markedly over a short period of time, a method for describing either the average character of the sound or the statistical behavior of the variations must be utilized. Most commonly, environmental sounds are described in terms of an average level that has the same acoustical energy as the summation of all the time-varying events. This energy-equivalent sound/noise descriptor is called L_{eq}. The most common averaging period is hourly, but L_{eq} can describe any series of noise events of arbitrary duration.

The scientific instrument used to measure noise is the sound level meter. Sound level meters can accurately measure environmental noise levels to within about plus or minus 1 dBA. Various computer models are used to predict environmental noise levels from sources, such as roadways and airports. The accuracy of the predicted models depends upon the distance the receptor is from the noise source. Close to the noise source, the models are accurate to within about plus or minus 1 to 2 dBA.

TABLE 1 Definitions of Acoustical Terms Used in this Report

Term	Definitions
Decibel, dB	A unit describing the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound measured to the reference pressure. The reference pressure for air is 20.
Sound Pressure Level	Sound pressure is the sound force per unit area, usually expressed in micro Pascals (micro Newtons per square meter), where 1 Pascal is the pressure resulting from a force of 1 Newton exerted over an area of 1 square meter. The sound pressure level is expressed in decibels as 20 times the logarithm to the base 10 of the ratio between the pressures exerted by the sound to a reference sound pressure (e.g., 20 micro Pascals). Sound pressure level is the quantity that is directly measured by a sound level meter.
Frequency, Hz	The number of complete pressure fluctuations per second above and below atmospheric pressure. Normal human hearing is between 20 Hz and 20,000 Hz. Infrasonic sound are below 20 Hz and Ultrasonic sounds are above 20,000 Hz.
A-Weighted Sound Level, dBA	The sound pressure level in decibels as measured on a sound level meter using the A-weighting filter network. The A-weighting filter de-emphasizes the very low and very high frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise.
Equivalent Noise Level, L_{eq}	The average A-weighted noise level during the measurement period. The hourly L_{eq} used for this report is denoted as dBA $L_{eq[h]}$.
Community Noise Equivalent Level, CNEL	The average A-weighted noise level during a 24-hour day, obtained after addition of 5 decibels in the evening from 7:00 pm to 10:00 pm and after addition of 10 decibels to sound levels in the night between 10:00 pm and 7:00 am.
Day/Night Noise Level, L_{dn}	The average A-weighted noise level during a 24-hour day, obtained after addition of 10 decibels to levels measured in the night between 10:00 pm and 7:00 am.
L_{01}, L_{10}, L_{50}, L_{90}	The A-weighted noise levels that are exceeded 1%, 10%, 50%, and 90% of the time during the measurement period.
Ambient Noise Level	The composite of noise from all sources near and far. The normal or existing level of environmental noise at a given location.
Intrusive	That noise which intrudes over and above the existing ambient noise at a given location. The relative intrusiveness of a sound depends upon its amplitude, duration, frequency, and time of occurrence and tonal or informational content as well as the prevailing ambient noise level.

TABLE 2 Typical Noise Levels in the Environment

Common Outdoor Noise Source	Noise Level (dBA)	Common Indoor Noise Source
	120 dBA	
Jet fly-over at 300 meters		Rock concert
	110 dBA	
Pile driver at 20 meters	100 dBA	
		Night club with live music
	90 dBA	
Large truck pass by at 15 meters		
	80 dBA	Noisy restaurant
		Garbage disposal at 1 meter
Gas lawn mower at 30 meters	70 dBA	Vacuum cleaner at 3 meters
Commercial/Urban area daytime		Normal speech at 1 meter
Suburban expressway at 90 meters	60 dBA	
Suburban daytime		Active office environment
	50 dBA	
Urban area nighttime		Quiet office environment
	40 dBA	
Suburban nighttime		
Quiet rural areas	30 dBA	Library
		Quiet bedroom at night
Wilderness area	20 dBA	
	10 dBA	Quiet recording studio
Threshold of human hearing	0 dBA	Threshold of human hearing

Since the sensitivity to noise increases during the evening and at night -- because excessive noise interferes with the ability to sleep -- 24-hour descriptors have been developed that incorporate artificial noise penalties added to quiet-time noise events. The *Community Noise Equivalent Level, CNEL,* is a measure of the cumulative noise exposure in a community, with a 5 dB penalty added to evening (7:00 pm - 10:00 pm) and a 10 dB addition to nocturnal (10:00 pm - 7:00 am) noise levels. The *Day/Night Average Sound Level, L_{dn},* is essentially the same as CNEL, with the exception that the evening time period is dropped and all occurrences during this three-hour period are grouped into the daytime period.

SUNNYVALE NOISE ORDINANCE

Section 19.42.030 of the Sunnyvale Municipal Code regulates noise levels as follows:

(a) Operational noise shall not exceed seventy-five dBA at any point on the property line of the premises upon which the noise or sound is generated or produced; provided, however, that the noise or sound level shall not exceed fifty dBA during nighttime or sixty dBA during daytime hours at any point on adjacent residentially zoned property. If the noise occurs during nighttime hours and the enforcing officer has determined that the noise involved is steady, audible tone such as a whine, screech, or hum, or is a staccato or intermittent noise (e.g., hammering) or includes music or speech, the allowable noise or sound level shall not exceed forty-five dBA.

(b) Power equipment used on a temporary, occasional or infrequent basis which produces a noise greater than the applicable operational noise limit set forth in Subsection (a) shall be used only during daytime hours when used adjacent to a property with a residential zoning district. Powered equipment used on other than a temporary, occasional or infrequent basis shall comply with the operational noise requirements. For the purpose of this section, powered equipment does not include leaf blowers. Construction activity regulated by Title 16 of this code shall not be governed by this section.

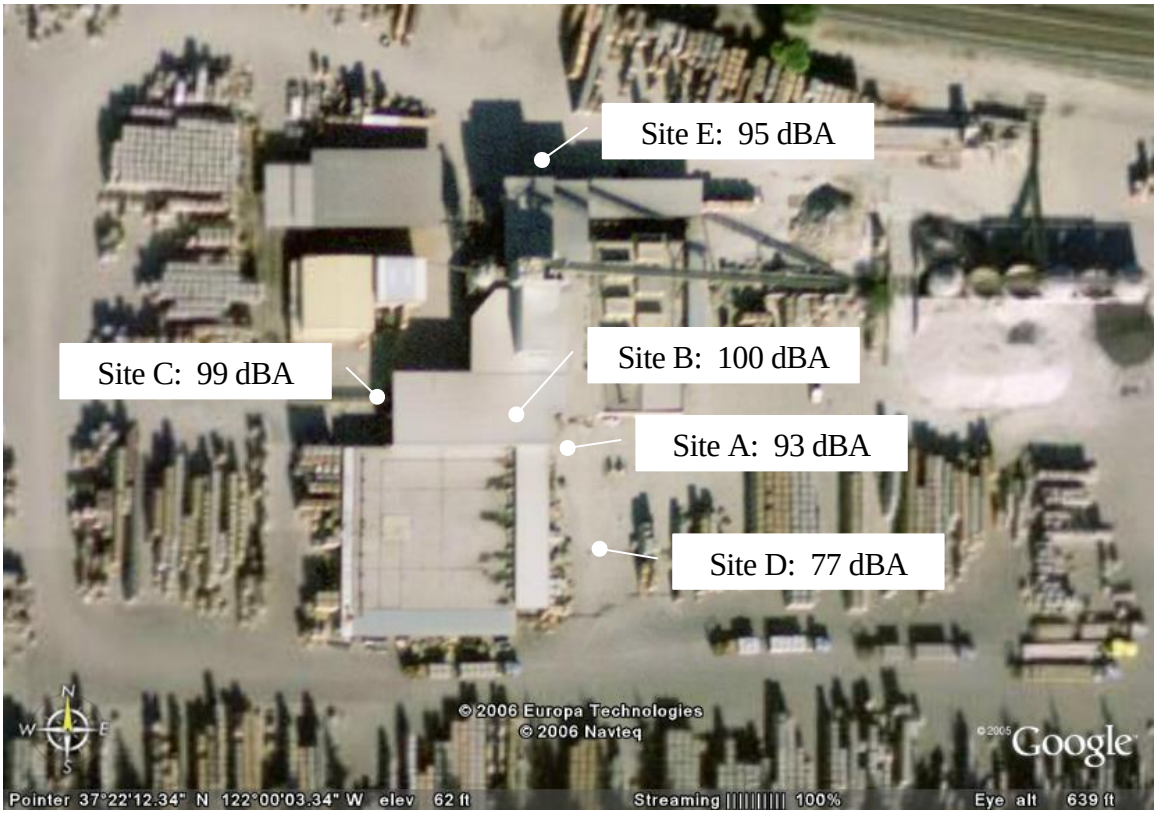
(c) It is unlawful for any person to make or allow to be made a nighttime delivery to a commercial or industrial establishment when the loading/unloading area of the establishment is adjacent to a property in a residential zoning district. Businesses legally operating at a specific location as of February 1, 1995 are exempt from this requirement.

(d) A “leaf blower” is a small …. Not applicable.

NOISE MONITORING SURVEY

A noise monitoring survey was conducted to quantify noise levels on the Calstone property adjacent to the Calstone and Peninsula Materials businesses and at significant noise sources within the Calstone property. Figure 1 shows the noise measurement locations. The upper aerial photograph shows the four locations around the site perimeter where noise levels were monitored over a 24-hour period. The lower aerial photograph shows the block manufacturing areas within the center of the Calstone site and the measured noise levels at locations surrounding and inside the building.

Figure 1 Noise Measurement Locations



Noise levels were measured with Larson-Davis Laboratories Model 700 and 820 integrating sound level meters fitted with precision microphones and windscreens. Instrumentation was calibrated with a Larson-Davis Laboratories acoustical calibrator. During the survey, observed winds were light at 0 to 5 miles per hour from the north, skies were clear, and temperatures were moderate during the daytime and the nighttime. Measurements were made in sequential 10-minute intervals.

LT-1: West Property Line. Noise measurement location LT-1 was selected near the western property boundary. Because of large stacks of manufactured blocks along the entire property line, the measurement was made at the top of a stack of blocks approximately 20 feet inside the property line, at approximately the same height as the top of the existing sound wall, and with an unobstructed view of the manufacturing area. Noise levels at the property line would be equal or lower than measured noise levels. Noise levels measured at location LT-1 are shown on Figure 2. The data show the maximum sound level, the average sound level (L_{eq}), and the sound level exceeded 90 percent of the time (L_{90}) during each 10-minute interval.

An attended measurement was made near location LT-1 between 3:47 and 3:57 PM on June 19, 2006. The maximum noise levels generated by the brick manufacturing plant and a forklift circulating down the main internal drive located east of the measurement location was 54 dBA. A truck in the same area, at a distance of approximately 75-100 feet from the monitoring location, generated a maximum noise level of 66 dBA as it left the yard loaded. A train generated a maximum noise level of 62 dBA. A review of the data in Figure 2 shows that from the time the measurement started at about 4:00 PM until about 5:30 AM, maximum noise levels were typically less than 70 dBA, although one event nearly reached 75 dBA. There was some activity that caused noise levels of 70-75 dBA with one event at 80 dBA in the early morning, and then regularly occurring noise levels between 75-80 dBA throughout the day. Based on observations made at this measurement location and others, which will be subsequently described, the likeliest source of the excursions above 75 dBA was forklift operations near the microphone.

LT-2: Aster Avenue Opposite the Manufacturing Building. Measurement location LT-2 was located along the Aster Avenue (southern) property boundary directly opposite the eastern edge of the block manufacturing building. This location was identified as a point where the maximum noise levels resulting from the block manufacturing equipment could be monitored near the property boundary. Stacks of concrete blocks all along the Aster Avenue property line made it difficult to measure representative credible worst case noise levels at the property line. A location was, again, selected on the top of a stack of blocks which afforded some shielding from Aster Avenue traffic, but provided the maximum possible noise exposure from the manufacturing area. Even at this location, there was some minimal shielding from some stacks of blocks. Noise levels measured at location LT-2 are shown on Figure 3.

Figure 2: Noise Levels at LT-1
June 19-20, 2006

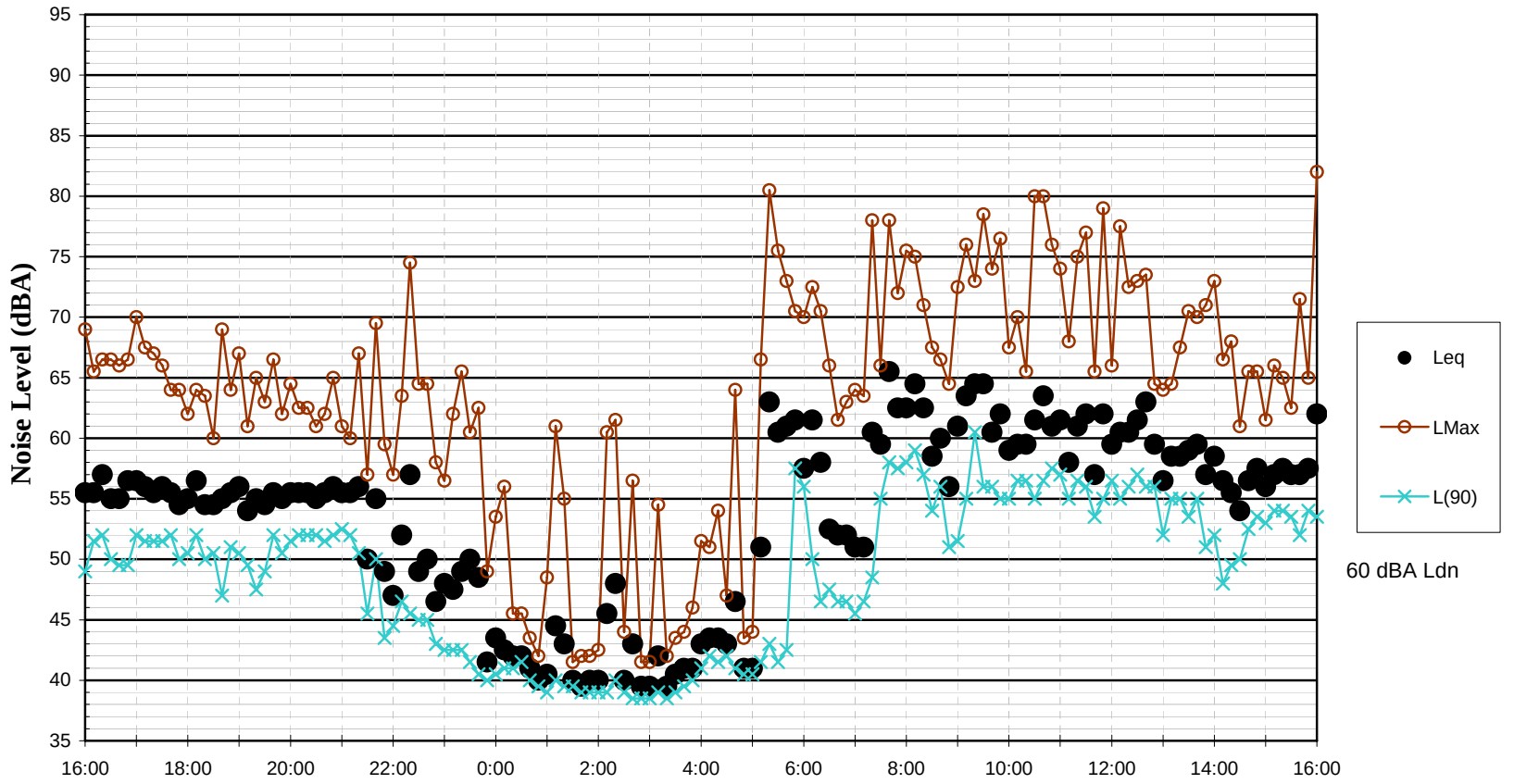


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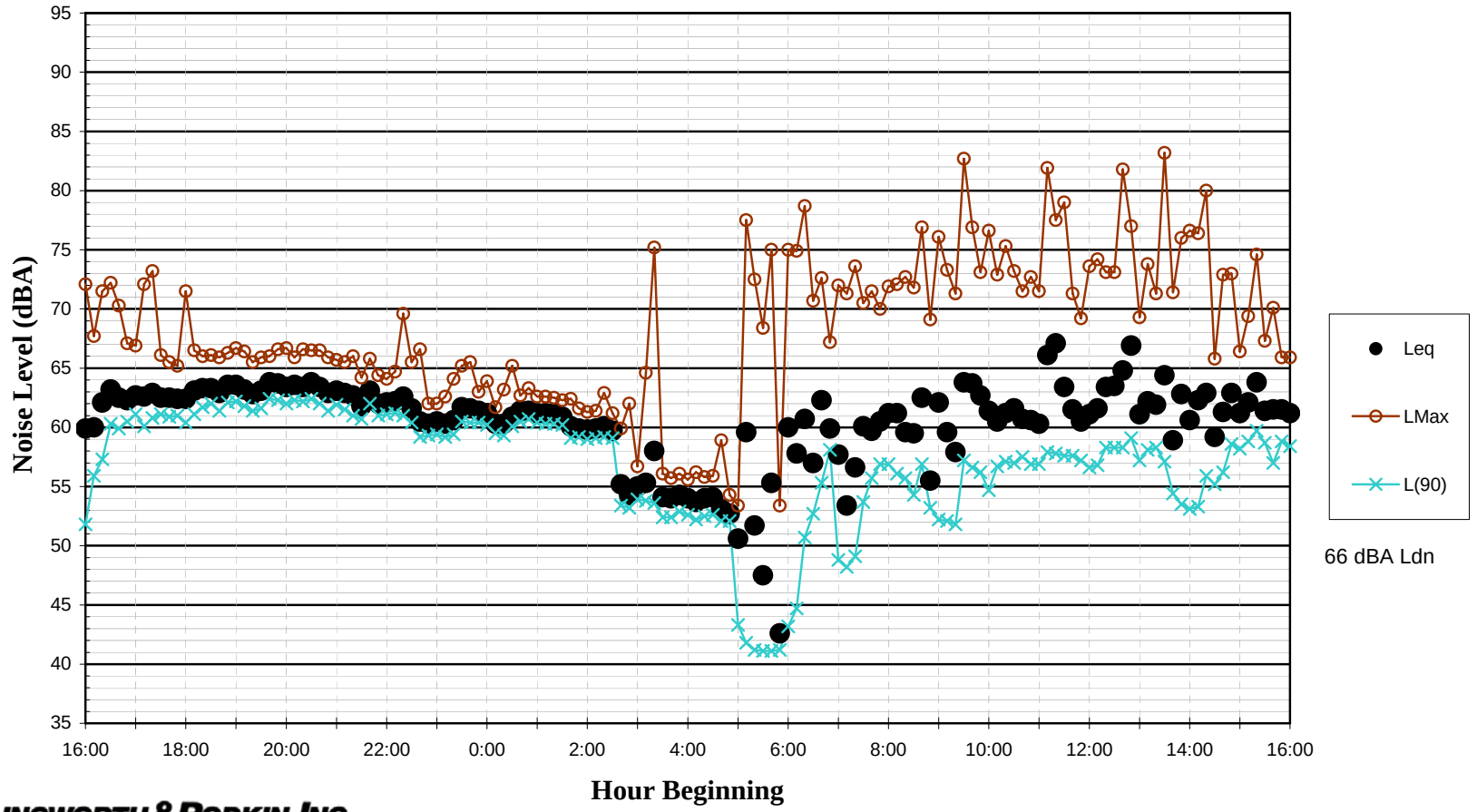
Figure 3: Noise Levels at LT-2
June 19-20, 2006



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An attended measurement was made between 4:10 PM and 4:20 PM. The brick-making machine generated a noise level of approximately 62-63 dBA when it cycled on. A forklift driving along the internal circulation way located north of the measurement location generated a noise level of 67 dBA at a distance of approximately 40 feet, the highest noise level generated during the attended measurement. A train passing by the property generated maximum noise levels of 63-64 dBA. This location was shielded from vehicular traffic on Aster Avenue and there was very light traffic in this segment of the roadway during this attended measurement.

The data in Figure 3 again show relatively low and steady noise levels throughout the afternoon of June 19, 2006. The maximum noise level of 75 dBA which occurred between 3:00 AM and 4:00 AM was likely due to a vehicle on Aster Avenue. The data again reflect an increase in activity after 5:00 AM with maximum noise levels occasionally exceeding 75 dBA and infrequently ranging up to 80-83 dBA. Based on our observations, these higher noise levels are likely attributable to traffic along Aster Avenue and/or forklift operations in the near vicinity of the microphone.

LT-3: Aster Avenue Just West of Calstone Entrance. Measurement location LT-3 was at the property line fence along Aster Avenue west of the entrance driveway to the Calstone facility. Because the measurement location was on the property line on the chain link fence, this location provided a measurement of Aster Avenue traffic as well as noise generation on the Calstone property. The sound level meter was at a point directly opposite where trucks park prior to exiting the facility. Long-term measurement data are shown on Figure 4.

An attended measurement was made between 4:30 PM and 4:40 PM on June 19, 2006. The most significant noise sources were automobiles and a truck on Aster Avenue with automobiles generating typical maximum noise levels ranging from 62-68 dBA and a medium-sized truck generating a maximum noise level of 78 dBA. The brick-making machine generated a maximum noise level of less than 50 dBA. The data in Figure 4 show regular exceedances of 75 dBA throughout the afternoon and evening, and again in the early morning and throughout the day. These exceedances resulted primarily from vehicular traffic on Aster Avenue. Occasional forklift operations near the sound level meter may also have caused levels exceeding 75 dBA.

LT-4: Aster Avenue at Peninsula Materials. Measurement location LT-4 was in front of the Peninsula Materials Company at a location in a tree along the Aster Avenue property boundary east of the entrance driveways to the site. Noise levels at this location were dominated by vehicular traffic on Aster Avenue. Occasional automobiles in the Peninsula Materials parking lot may have contributed, but not to a significant level. There are no other significant sources of noise on the Peninsula Materials site that would have contributed to measured noise levels except perhaps a forklift or truck. Measurement location LT-4, therefore, is believed to represent Aster Avenue traffic noise in the eastern portion of the study area. The measured data from the long-term measurement are shown in Figure 5. It can be seen that vehicular traffic along Aster Avenue generates noise levels exceeding 75 dBA throughout the daytime, evening, and nighttime. Because most traffic accesses the site from Willow and Aster, this is believed to represent the worst case noise levels resulting from

Figure 4: Noise Levels at LT-3
June 19-20, 2006

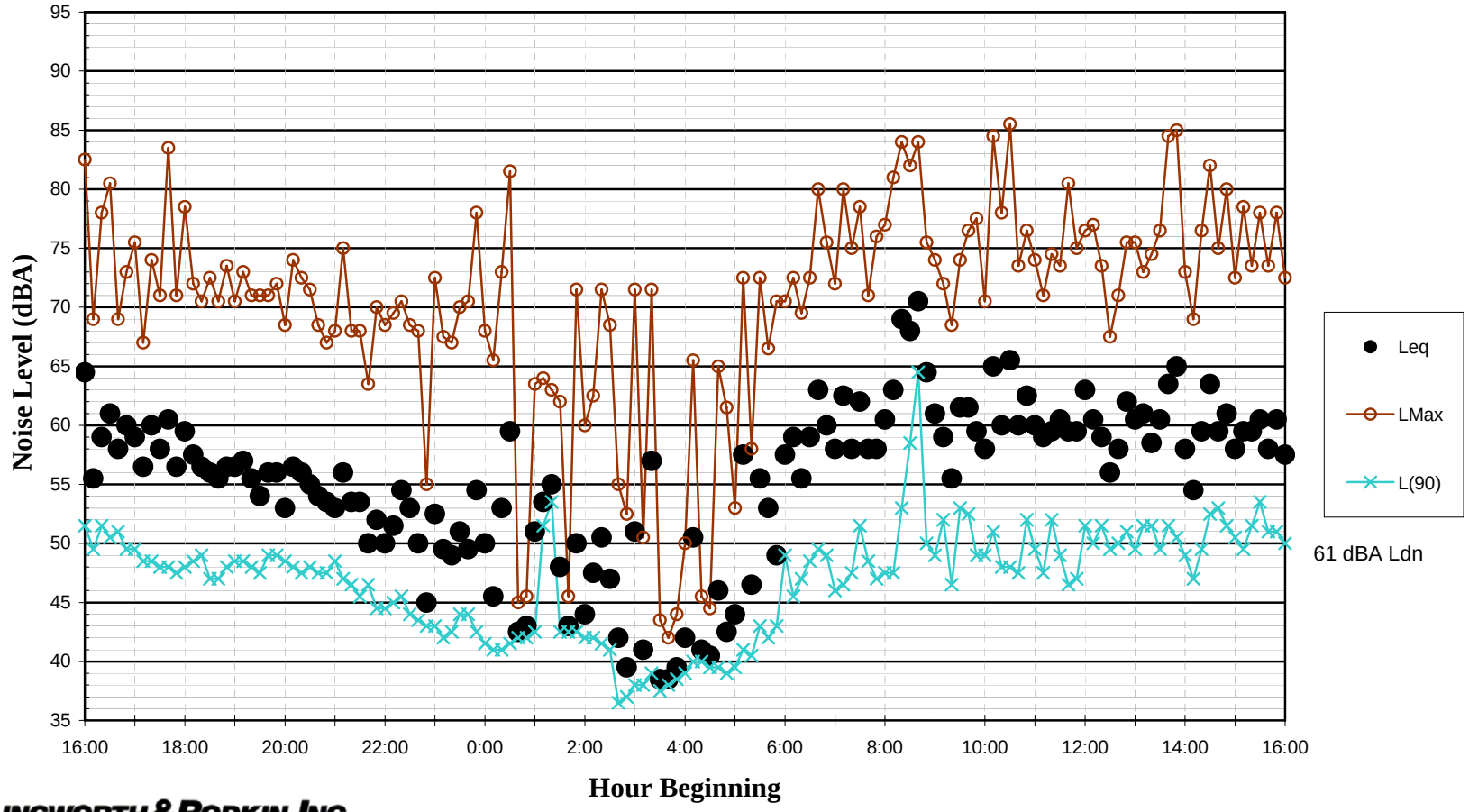

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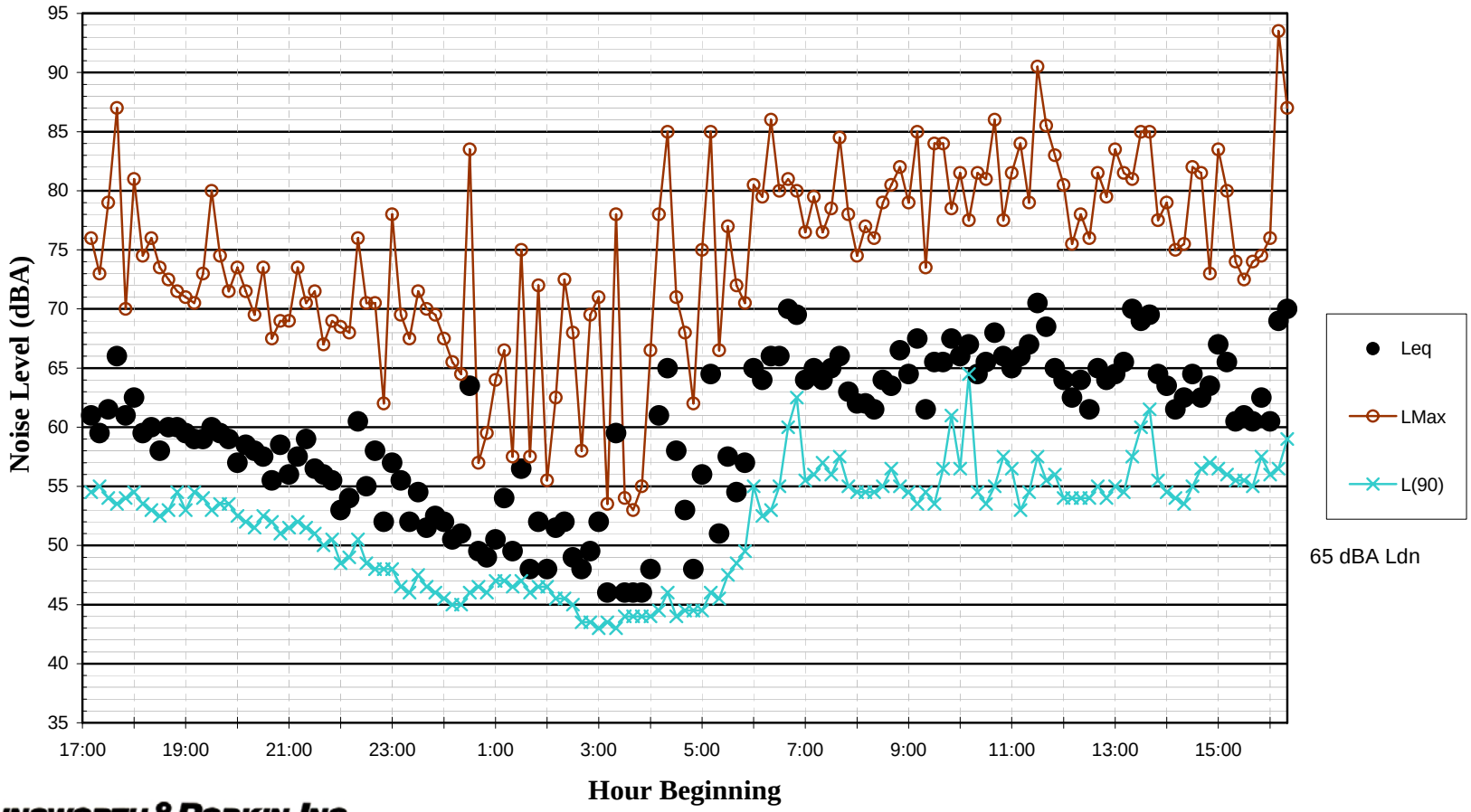
Figure 5: Noise Levels at LT-4
June 19-20, 2006



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traffic noise on Aster Avenue. The 24-hour day/night average noise level resulting from the vehicular traffic along Aster Avenue was 65 dBA L_{dn}. This measurement correlated fairly closely to the data reported by Veneklasen.[1]

Close-In Measurements at Calstone. The most significant noise sources on the Calstone property were identified by Mr. Matt Morey of Calstone and confirmed by our observations to be the equipment located in the block manufacturing building located near the site center and forklifts which operate throughout the property. Trucks occasionally generate noise levels on the site when they start their engines, circulate within the interior portions of the site, and turn off their engines which causes an air release noise. Some trucks at the entrance driveway bounce and rattle as they cross the gate guide in the pavement. Because of the substantial amount of shielding provided by the stacked blocks, the circulating trucks are not considered to be a significant source of noise beyond the project's property boundaries. Technically, however, a truck could cause a noise level exceeding 75 dBA at the project's property boundary when it enters the project site at the driveway. Application of the noise ordinance to a truck at the entrance driveway is not, in our opinion, appropriate because it would cause a violation at virtually every industrial property.

Measurements were made of a diesel-powered forklift. Two noise sources are associated with the forklift, the diesel engine and the backup alarm (beeper), which sounds when the forklift is placed in reverse. The maximum measured noise level generated by a forklift engine was 67 dBA at a distance of 40 feet. This would equate to a maximum noise level of approximately 87 dBA at a distance of 4 feet and could occur when an engine is revving to lift a load or when the forklift is accelerating. The backup beeper generated a noise level of approximately 97 dBA at 4 feet behind the forklift, 90 dBA at 10 feet behind the forklift, and 72 dBA at 5 feet in front of the forklift. Backup beepers are, of course, highly directional and intended to warn persons who are standing behind the forklift when it is backing up.

The lower photograph in Figure 1 shows noise measurements made in and around the block manufacturing building. The A-weighted noise levels shown on Figure 1 represent the maximum noise levels measured when the concrete products manufacturing machine is cycling into its noisiest mode. This is an open-sided building. Site A was at the façade of the open southeast corner, Site B was inside the building, Site C was on the western side of the building immediately adjacent to the block manufacturing machine, Site D was located at a distance of 100 feet from Site A (and is used as the reference source level), and Site E was located on the north side of the building adjacent to the second block manufacturing machine. Utilizing the measurement at Site D, a worst case property line noise level can be calculated along the Aster Avenue frontage resulting from the manufacturing area. The distance from the corner of the manufacturing building at Site A to the property line was estimated from an aerial photograph to be 260 feet. The predicted worst case noise level at the Calstone property line resulting from the block manufacturing machine is 68-69 dBA, assuming no stacks of blocks to provide acoustical shielding. According to Calstone, these stacks of blocks are typically present. Noise levels are not expected to exceed 62-63 dBA measured at long-term site LT-2 and may be expected to be substantially lower along most of the property line as a result of the extensive shielding provided by the stacks of blocks.

[1] Letter from John Gorr and Wayland Dong, Veneklasen Associates, to Mr. James Lindsay, KB Home South Bay, dated December 20, 2005, revised May30, 2006.

COMMENTS ON THE NOISE VIS-À-VIS THE ORDINANCE

The noise ordinance regulates noise levels at the Calstone property line and would regulate noise levels at any adjacent residential properties. Currently, there is an adjacent residential property located on the west side of the Calstone site. There is a high wall, estimated to be approximately 15 feet high, located on the western property line. A parking lot on the residential property adjoins the Calstone property. The sound wall would provide approximately 10-15 dBA of noise reduction, depending upon the height of the receiver on the residential property. A reasonable interpretation of the noise ordinance would allow the benefit of the sound wall to be included in an assessment of noise levels generated on the Calstone property with respect to the noise ordinance. Taking into account distance from the property line to the nearest residences and the effects of the sound wall, it is estimated that noise generated at Calstone would comply with both the industrial 75 dBA noise limit (measured at a point 5 feet above the ground behind the sound wall) and the residential noise limits applied at the nearest residential units.

Along Aster Avenue, noise from the **manufacturing** plant would meet the 75dBA noise level limit everywhere along the property line. If worst case noise levels from the manufacturing plant (no shielding from stacks of blocks) are projected across the street, the maximum expected level could reach 67 dBA on the residential property. This would exceed both the daytime and nighttime noise limits of 60 dBA and 50 dBA, respectively, that could be applicable at a neighboring residential property. In actuality, the stacked blocks would result in noise levels approximately 10-15 dBA lower, at least at first- or second-story locations. Nonetheless, noise levels could exceed the residential noise limit.

Forklifts operate along the Aster Avenue property boundary just inside the fence because they must be able to access both sides of the stacks of blocks in order to accommodate the various types of materials that are manufactured.[2] Most forklift operations occur between about 6:00 AM and 5:00 PM but a forklift may operate at any time when the facility is operating. Because the forklifts are operating very close to the property line, they intermittently generate noise levels above 75 dBA, both as a result of the engine and the backup beeper. As discussed previously, engine noise could be as high as 87 dBA and beeper noise could be as high as 97 dBA. Noise levels resulting from forklift operations along the Aster Avenue property line just inside the fence would also intermittently exceed the residential noise limits across the street. While the engine noise would cause a technical violation of the noise ordinance, it would not be noticeably different than typical vehicular traffic noise levels generated by vehicle passbys along Aster Avenue. Noise levels from the forklift engines would be lower than noise levels generated by trucks on Aster Avenue which would be passing closer to the residences. The occasional noise from the forklift engines would not make a measurable difference in the hourly or daily average noise levels at the residences across the street.

[2] Personal communication with Matt Morey, Calstone, 6/19/06.

The sound of the backup alarm is a different matter. Backup beepers are a frequent source of complaints from residents, whether they occur during the daytime, evening, or nighttime. Backup alarms are regulated by CAL OSHA. Backup alarms must generate a noise level at least 5 dBA above the background noise in the vicinity of the rear of the machine where a person would be warned by the alarm. Because forklifts operate in quiet areas near the property line and in noisy areas near the block manufacturing equipment, a constant level backup alarm must be set at a high enough amplitude to be clearly heard in the noisiest area. In this situation, the 97 dBA at 4 feet setting is appropriate for a fixed level backup alarm. Variable level backup alarms are also manufactured. These alarms measure the background sound between the beeps and vary the amplitude so as to generate an OSHA compliant level.

OVERALL FINDINGS AND RECOMMENDATIONS

(1) Operations on the Calstone site, with the exception of forklifts operating very close to Calstone's property line, comply with the 75 dBA industrial noise level limit applied at Calstone's property line.

(2) Worst case noise levels generated by the manufacturing facility and mobile sources at the Calstone facility are expected to exceed the residential daytime (60 dBA) and nighttime (50 dBA) noise limits if applied on the proposed residential project site across Aster Avenue.

The following item should be considered for noise control:

(1) Install new variable volume backup alarms on the forklifts. This would reduce property line noise levels from the backup alarms by up to 15 dBA.

The following additional measures were suggested by Calstone:

(2) Recess the gate guide (a steel strip on the driveway) at the front entrance to below the asphalt grade to prevent empty trucks from bouncing and generating high noise levels.

(3) Put up a truck sign inside the gate at the front entrance that says "Noise Sensitive Area, Minimize Engine Revving, Gear Grinding", etc.